THE EFFECTS OF PRESCRIBED FIRE ON FOREST FUEL DISTRIBUTIONS EIGHT AND ELEVEN YEARS AFTER BURNING

A CASE STUDY

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~~F. C. Fischer~~

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FINAL REPORT FOR COOPERATIVE AGREEMENT
0. 22-C-3-INT-28-CA, Fire management
lanning and evaluation in the
orthern Rockies, with SYSTEMS FOR
NVIRONMENTAL MANAGEMENT.
o-op contact: Collin D. Bevins
'S contact: James K. Brown

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ffects of prescribed fire on forest
ıel distributions eight and eleven
ears after burning.

oward Creek fuels management plan.

ost-fire vegetation and fuel succession
- the White Cap wilderness study area:
- 1980.

Lubrecht Experimental Forest

1972 - 1983

submitted by

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PREFACE

This paper is submitted in fulfillment of Section I. C. of Cooperative Aid Agreement No. 22-C-3-INT-28-CA, Amendment No. 1, between Systems for Environmental Management, P.O. Box 3776, Missoula, MT 59806, and the USDA Forest Service, Intermountain Forest and Range Experiment Station, Ogden, UT 84401.

INTRODUCTION

A prescribed fire study was initiated in 1972 in an attempt to quantify the relationships between measured prefire stand and fuel variables, observed fire behavior, and measured postfire stand and fuel variables (Norum 1975). The study was conducted within a mature western larch / Douglas-fir type (SAF Type 212) on the University of Montana Lubrecht Expertimental Forest.

Thirty-two test plots were inventoried for dead and down woody fuels before burning in 1972. Twenty plots were burned that year and re-inventoried in 1973 and 1975. All thirty-two plots were again inventoried for fuels in 1980 and 1983.

This paper reports the results of the fuel inventories stratified by inventory year, fuel type, and prescribed fire treatment type.

FIELD METHODS

The study site was divided into eight burning blocks which were further subdivided into four plot measuring 115-feet square. Nine of the thirty-two plots were burned in the spring of 1972, eleven were burned in the fall of 1972, and the remaining twelve were left unburned.

A prefire fuel inventory was conducted on all thirty-two plots in 1972 using the standard dead and down fuel inventory technique (Brown 1974). Measured fuel characteristics include duff fuel depth and loads of 1-hour, 10-hour, 100-hour, 1000-hour sound, and 1000-hour rotten fuels. The inventory consisted of thirteen randomly oriented transects anchored to permanently marked points.

Postfire fuel inventories were conducted in 1973 and 1975 on burned plots. Unburned plots were not re-inventoried at that time. While sample transects were anchored to the same thirteen permanent points, their azimuths were again randomly selected independent of the preburn inventory azimuths.

A complete postfire inventory was conducted in 1980 and 1983 on all thrity-two plots. Both inventories used the same thirteen sample points (randomly oriented). The 1983 inventory used an additional 12 sample points for a total of 25 points per plot.

ANALYSIS METHODS

The field tally sheets for the five fuel inventories were used to create a data file which was processed by a FORTRAN fuel load conversion program to determine fuel loads. Summary statistics were produced for each fuel type, plot, and inventory year. The results showed that (1) populations for all fuel types were significantly skewed, and (2) population standard deviations were typically in excess of 100% of the mean.

Remaining analyses were restricted to nonparametric tests of sample transect populations pooled by treatment type. That is, stratification by plot was dropped in favor of stratification by treatment type across plots, Sample points within plots were pooled into classes according to three stratification schemes:

(1) (a) sample points from unburned plots
    (b) sample points from burned plots

(2) (a) sample points from unburned plots
    (b) sample points from plots with 1- to 25-percent of the plot area burned
    (c) sample points from plots with 26- to 60-percent of the plot area burned
    (d) sample points from plots with more than 60-percent of the plot area burned

(3) (a) sample points from unburned plots
    (b) sample points from plots which were burned in the spring (May-June) of 1972

(c) sample points from plots which were burned in the fall (September-October) of 1972

Differences between fuel populations were tested using the Kolmogorov-Smirnov (K-S) 2-sample test and the Mann-Whitney (M-W) U test. The K-S procedure tests the homogeneity (equality) of two distributions. This test is sensitive to any type of difference in the two distributions; median, dispersion, skewness, etc. The observed cumulative distributions for both groups are derived and the K-S Z score is computed from the maximum positive, negative, and absolute differences.

The M-W also tests whether two samples are from the same population. The two sample groups are combined and cases are ranked in increasing size. The test statistic U is computed as the number of times a score from group 1 precedes a score from group 2. The rationale is that if the samples are from the same population the distribution of scores from the two groups in the ranked list will be random.

Both tests were applied to pairs of fuel population classes within each stratification scheme. The resulting two-tailed probability levels (p) were used to determine significant differences. Medians were used as the best expression of fuel population central tendency.

RESULTS

Tables 1a through 1c contain medians of duff depth, fine fuel load (1-, 10-, and 100-hour fuels), and large fuel load (1000-hour sound and rotten fuels), respectively, by plot and inventory year. Plots are ranked by percent of plot area burned. The tables also include percent change in the median value from the 1972 pretreatment level.

Tables 2a through 2c contain the mean, standard error, median, and number of sample transects by inventory year and treatment class within each stratification.

Tables 3a through 3c show the results of the K-S and M-W tests between treatment class pairs within each stratification.

The change in fuel population medians shown in tables 2a through 2c are displayed in the graphs contained in figures 1 through 3. Figures 1a through 1c show changes over time in median duff depth, fine fuel load, and large fuel load, respectively, between burned and unburned sample classes. Figures 2a through 2c illustrate fuel changes over time by four ′percent of plot area burned′ sample classes. Figures 3a through 3c display fuel changes over time by season of burning class.

Finally, table 4 gives a breakdown of median fuel values by inventory year for each of the six individual fuel classes. Values are stratified by percent of plot area burned class. Percent change in the median values from the 1972 prefire inventory are included.

DISCUSSION

The discussion of study results will center on comparisons of duff depth, fine fuel load, and large fuel load populations between treatment types for inventory years 1972, 1980 and 1983. A comparison of 1972 populations between scheduled treatment types is important in determining if prefire fuel conditions were the same across plots regardless of scheduled treatment. If significant differences are found, then postfire differences cannot be attributed soley to treatment effects. No discussion is made of the 1973 and 1975 inventories because there is no control population upon which to base comparisons.

Duff Fuel Depths

Unburned vs. Burned Samples

Pretreatment duff depths on burned and unburned sample points were not statistically different ($p < 0.05$) by either the K-S or M-W tests (table 3a). Duff depths on burned plots were significantly lower ($p < 0.001$) than on unburned plots in both the 1980 and 1983 inventories. Median duff depths on unburned plots for the two years were 1.73- and 1.79-inches, respectively. Corresponding duff depths on burned plots were 1.00-inches (57-percent of the unburned sample median) and 0.85-inches (47-percent).

Unburned Samples vs. Samples in Low, Moderate, and High Percent of Plot Area Burned Classes

Pretreatment duff depth distributions were generally not significantly different between unburned samples and samples in the low, moderate, and high percent of plot area burned classes. The single exception occurred between

the unburned and moderate burn categories for the K-S test only.

The table below summarizes median duff depths by treatment level and inventory year. Treated sample medians are also expressed as a percentage of the untreated median for that year. An asterisk indicates that the treated sample distribution is significantly different ($p < 0.001$) from the untreated sample.

	----- Duff Depths -----			
	-- 1980 --		-- 1983 --	
Plot Area Burned	Median	%	Median	%
Unburned	1.73		1.79	
1% - 25%	1.49	86%	1.26*	70%
25% - 60%	0.98*	57%	0.91*	51%
> 60%	0.51*	29%	0.55*	31%

The table shows that, as expected, duff depths decline with increasing completeness-of-burn. Furthermore, table 3a shows that differences in duff depth distributions are highly significant between burn completeness categories for the two years.

Unburned Samples vs. Samples Burned in the Spring and Fall

Pretreatment duff depth distributions were not significantly different ($p < 0.05$) between (1) unburned and spring burned samples, nor (2) spring burned and fall burned samples by either the K-S or M-W tests. Significant pretreatment differences were found between (3) unburned and fall burned samples.

Duff depths on samples burned in the spring were highly significantly different ($p < 0.001$) than on unburned plots in 1980 and 1983. Unburned sample medians were 1.73-inches (1980) and 1.79-inches (1983) compared to

1.35- (78-percent) and 1.30-inches (73-percent) on spring burned samples.

While duff depths on plots burned in the fall were also highly significantly lower than on unburned plots in 1980 and 1983, the two populations were significantly different before burning. Median duff depths on fall burned plots were 45- and 34-percent of the unburned plot medians in 1980 and 1983, respectively.

Significant differences in duff depth distributions between samples burned in the spring and those burned in the fall were still evident in 1980 and 1983. Samples burned in the fall had median duff depths of 0.77-inches (1980) and 0.61-inches (1983), or 57- and 47-percent of those burned in the spring. Plots burned in the spring averaged 36-percent of plot area burned, while those burned in the fall averaged 50%.

Fine Fuel Loads

Unburned vs. Burned Samples

Pretreatment fine fuel loads on burned and unburned sample points were not significantly different ($p < 0.05$) by either the K-S or M-W tests (table 3b). The two classes remained statistically indistinct after treatment as recorded by the the 1980 and 1983 inventories.

Unburned Samples vs. Samples in Low, Moderate, and High Percent of Plot Area Burned Classes

Pretreatment fine fuel loads were not significantly different between unburned samples and samples in plots with more than 25-percent of the plot area burned. The K-S test showed a significant pretreatment difference ($p < 0.05$) between unburned samples and samples in the low burn class.

A significant difference between levels of treatment after burning

occurred between unburned samples and samples in the high burn class in 1983. The median 1983 fine fuel load on unburned plots was 3.03-tons per acre (table 2b). The median load on high burn class samples was 35-percent higher, or 4.11-tons per acre.

1983 fine fuel loads in the low and moderate burn classes were also statistically different from those in the high burn class. Furthermore, the low and moderate burn class distributions were distinct according to the M-W test. The 1980 inventory failed to show significant differences between any of these pairings.

The fine fuel loads in 1983 show an increase in loading with increasing percent of plot area burned. Fine fuel medians were 2.26-tons per acre for the low class, 3.24-tons per acre for the moderate class, and 4.11-tons per acre for the high class. In summary, while burned samples in different classes are distinct from one another, only the high burn class is distinct from unburned samples.

Unburned Samples vs. Samples Burned in the Spring and Fall

Pretreatment fine fuel loads were not statistically different ($p < 0.05$) between unburned samples, samples burned in the spring, and samples burned in the fall. These populations remained statistically indistinct in the 1980 and 1983 inventories.

Large Fuel Loads

Unburned Samples vs. Burned Samples

Pretreatment large fuel loads were not statistically different ($p < 0.05$) between samples scheduled for burning and those left unburned (table 3c). The M-W test shows differences in the post-treatment populations in 1980, and both

tests found highly significant differences ($p < 0.001$) in the 1983 inventory. The 1983 median large fuel load was 7.71-tons per acre on unburned plots and 4.23-tons per acre on burned plots, a 46-percent reduction. Median fuel loads in 1980 were zero tons per acre for both classes.

Unburned Samples vs. Samples in Low, Moderate, and High Percent of Plot Area Burned Classes

Pretreatment large fuel loads were not significantly different between unburned samples and samples in plots with more than 25-percent of the plot area burned. The same situtation occurred in the fine fuels. Both the K-S and M-W tests showed highly significant pretreatment differences ($P < 0.01$) between samples in the low burn class and samples from all other classes.

Samples in both the moderate and high percent of plot area burned classes were significantly different from unburned samples in 1983, but not in 1980. This again parallels the findings for the fine fuel loads. Median large fuel loads on unburned samples were 7.71-tons per acre, 4.16-tons per acre for the moderate burn class, and 4.13-tons per acre for the high burn class. In contrast to the fine fuel populations, the moderate and high burn classes were never statistically distinct for large fuels.

Unburned Samples vs. Samples Burned in the Spring and Fall

Pretreatment large fuel loads were not statistically distinct between unburned samples, samples burned in the spring, and samples burned in the fall.

Large fuel loads on plots burned in the fall were significantly different ($p < 0.05$) from large fuels on unburned plots in 1980 and 1983. Plots burned in the spring did not have large fuel loads different from unburned plots for

either year. Median large fuel loads in 1980 were 0.00-tons per acre for all three treatments. Median large fuel loads in 1983 were 7.71-tons per acre on unburned plots, 5.62-tons per acre on plots burned in the spring, and 2.71-tons per acre on plots burned in the fall.

CONCLUSIONS

Effects of Burning vs. Not Burning

Prescribed burning significantly ($p < 0.05$) affected duff depths eight and eleven years after burning. Duff depths on burned sites were typically half those on unburned sites.

No significant burning effects were found on fine fuel loads after eight or eleven years.

Large fuel loads were significantly reduced by burning in the 1983 inventory, but not in the 1980 inventory. In both years mean and median large fuel loads on burned sites were approximately half those on unburned sites.

Effects of Burn Completeness

Duff fuel depths are significantly affected by completeness of burn class eight and eleven years after burning. As a rule of thumb, the percent reduction in duff depth a decade after burning is roughly equivalent to the percent of plot area burned. For example, a 60-percent burn on a site averaging 2-inches of duff yields 0.8-inches of duff after ten years.

Fine fuel loads were significantly affected only on plots with more than 60-percent of the plot area burned. Fine fuel loads increased with increasing burn completeness both eight and eleven years after burning. Plots with less than 25-percent area burned had lower loads than unburned plots, while plots

with more than 25-percent area burned had loads higher than unburned plots.

Large fuel loads were significantly reduced on plots with over 25-percent plot area burned eleven years after treatment (effects were not significant after eight years). Large fuel loads were reduced by about 50-percent. Mean large fuel loads in 1983 were reduced by about the same percentage as plot area burned, following the rule of thumb described above.

Effects of Burning Season

Season of burning had a significant effect on duff fuel depths. Spring burns averaged 36-percent of plot area burned while fall burns averaged 50-percent. Reduction in duff depths by season follows the rule of thumb discussed previously; spring fires reduced duff depths to 72-percent of depths on unburned plots, and fall fires reduced duff depths to 34-percent.

Season of burning has no significant nor apparent effects on fine fuel loads eight and eleven years after treatment.

Fall burning significantly reduced large fuel loads by 65-percent, consistent with the rule of thumb. While spring burning effects were not statistically significant ($p < 0.05$), spring burning apparently reduced large fuels by 17-percent, again roughly following the rule of thumb.

Effects of Burning on Lubrecht Experimental Forest Fuels

Prescribed fire appears to have a significant effect on duff and large fuel loads up to a decade after burning. These two fuel types generally accumulate slowly and steadily over time, while fine fuels may accumulate as a result of more rapid processes. Two inferences may be ventured from the study results;

(1) The rule of thumb which applies to duff and large fuels is that fire

reduces their loads proportional to the completeness of burn. This may be entirely due to the possibility that fire reduces these fuels by 100-percent on burned patches and by 0-percent on unburned patches.

(2) Since fire reduced duff and large fuel loads by about 50-percent over a ten-year period, we may expect fire effects to disappear after about 20 years.

PUBLICATION CITED

Brown, James K.

1974. Handbook for inventorying downed woody material. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. INT-16, 24p. Intermtn. For. and Range Exp. Stn., Ogden, UT.

Norum, Rodney A.

1975. Characteristics and effects of understory fires in western Montana larch/Douglas-fir stands. Unpublished Phd. dissertation. Univ. of Mont., Missoula, MT.

TABLES

Table 1 a

Changes in Median Duff Depths

Lubrecht Experimental Forest
1972 - 1983

Plot Numb	Area Burned	1972 Depth	---1973--- Depth	Change	---1975--- Depth	Change	---1980--- Depth	Change	---1983--- Depth	Change
	(%)	(Inch)	(Inch)	(%)	(Inch)	(%)	(Inch)	(%)	(Inch)	(%)
Burned Plots										
30	13	2.49	2.49	0	0.55	-78	1.95	-22	2.10	-16
29	19	2.52	0.92	-63	0.36	-86	1.10	-56	1.48	-41
14	22	1.61	1.44	-11	0.36	-78	1.30	-19	0.33	-80
5	30	2.52	1.21	-52	0.46	-82	1.40	-44	1.03	-59
3	31	1.44	0.39	-73	0.21	-85	0.65	-55	0.25	-83
27	36	1.97	1.01	-49	0.46	-77	0.65	-67	0.91	-54
28	37	1.47	0.92	-37	0.48	-67	1.60	9	0.85	-42
25	39	1.80	0.75	-58	0.40	-78	1.85	3	0.93	-48
31	40	1.80	1.26	-30	0.50	-72	0.93	-48	0.60	-67
6	40	2.76	1.31	-53	0.45	-84	1.71	-38	1.70	-38
9	43	2.36	1.84	-22	0.45	-81	0.91	-61	2.03	-14
23	43	2.31	1.31	-43	0.36	-84	1.15	-50	0.65	-72
18	47	2.10	0.62	-70	0.20	-90	0.26	-88	1.10	-48
28	48	1.47	0.92	-37	0.48	-67	1.60	9	0.85	-42
10	50	2.89	0.79	-73	0.43	-85	1.00	-65	0.97	-66
2	53	2.36	0.82	-65	0.41	-83	0.60	-75	1.01	-57
1	66	1.80	0.26	-86	0.18	-90	0.30	-83	0.75	-58
22	68	2.72	0.00	-100	1.67	-39	0.16	-94	0.10	-96
11	70	2.00	0.74	-63	0.28	-86	0.75	-63	0.85	-58
21	76	3.41	0.11	-97	0.25	-93	0.50	-85	0.43	-87
Unburned Plots										
4	0	3.41	---	---	---	---	1.35	-60	1.10	-68
7	0	2.62	---	---	---	---	1.88	-28	2.80	7
8	0	2.10	---	---	---	---	2.25	7	3.20	52
12	0	3.81	---	---	---	---	2.56	-33	0.80	-79
13	0	1.84	---	---	---	---	1.45	-21	1.36	-26
15	0	2.06	---	---	---	---	1.50	-27	1.45	-30
16	0	1.84	---	---	---	---	1.61	-13	0.81	-56
17	0	3.41	---	---	---	---	2.75	-19	2.90	-15
19	0	1.57	---	---	---	---	1.80	15	1.65	5
20	0	2.89	---	---	---	---	0.83	-71	2.01	-30
24	0	2.10	---	---	---	---	1.30	-38	2.60	24
32	0	3.81	---	---	---	---	2.50	-34	1.60	-58

Table 1 b

Changes in Median Fine Fuel Loads

Lubrecht Experimental Forest
1972 - 1983

Plot Numb	Area Burned	1972 Load	---1973--- Load	Change	---1975--- Load	Change	---1980--- Load	Change	---1983--- Load	Change
	(%)	(Tons)	(Tons)	(%)	(Tons)	(%)	(Tons)	(%)	(Tons)	(%)
Burned Plots										
30	13	1.16	3.80	228	0.50	-57	1.57	35	3.32	186
29	19	1.74	1.67	-4	0.96	-45	1.54	-11	2.03	17
14	22	0.81	0.81	0	2.34	189	1.79	121	2.00	147
5	30	1.15	0.60	-48	1.77	54	1.61	40	2.44	112
3	31	3.19	0.61	-81	1.32	-59	2.49	-22	1.80	-44
27	36	4.91	4.38	-11	3.63	-26	5.07	3	4.71	-4
28	37	4.00	3.55	-11	2.24	-44	0.91	-77	1.95	-51
25	39	3.78	6.70	77	3.07	-19	4.53	20	4.06	7
31	40	4.42	1.29	-71	2.20	-50	1.24	-72	2.46	-44
6	40	3.87	3.52	-9	2.93	-24	2.79	-28	4.02	4
9	43	4.20	0.79	-81	1.57	-63	1.47	-65	4.44	[illegible]
23	43	4.30	1.27	-70	2.61	-39	1.71	-60	3.37	-22
18	47	4.08	1.50	-63	1.39	-66	1.48	-64	2.71	-34
28	48	4.00	3.55	-11	2.24	-44	1.91	-52	1.95	-51
10	50	3.36	0.94	-72	0.89	-74	0.66	-80	0.00	-100
2	53	3.10	1.96	-37	1.50	-52	1.72	-45	2.21	-29
1	66	1.09	0.31	-72	1.04	-5	3.04	179	2.89	165
22	68	6.77	3.66	-46	6.33	-6	9.75	44	6.63	-2
11	70	1.59	1.34	-16	2.88	81	1.16	-27	4.38	175
21	76	3.46	0.40	-88	0.64	-82	4.34	25	0.00	-100
Unburned Plots										
4	0	1.05	---	---	---	---	2.21	110	3.07	192
7	0	2.66	---	---	---	---	3.27	23	3.59	35
8	0	1.37	---	---	---	---	2.71	98	1.70	24
12	0	7.76	---	---	---	---	2.42	-69	4.27	-45
13	0	1.79	---	---	---	---	1.05	-41	1.38	-23
15	0	1.22	---	---	---	---	1.97	61	1.84	51
16	0	2.75	---	---	---	---	1.55	-44	2.40	-13
17	0	6.39	---	---	---	---	6.45	1	4.81	-25
19	0	2.46	---	---	---	---	0.93	-62	2.59	5
20	0	4.65	---	---	---	---	3.32	-29	4.04	-13
24	0	4.53	---	---	---	---	3.80	-16	4.03	-11
32	0	3.11	---	---	---	---	1.71	-45	3.19	3

Table 1 c

Changes in Median Large Fuel Loads

Lubrecht Experimental Forest
1972 - 1983

Plot Numb	Area Burned	1972 Load	---1973--- Load	Change	---1975--- Load	Change	---1980--- Load	Change	---1983--- Load	Change
	(%)	(Tons)	(Tons)	(%)	(Tons)	(%)	(Tons)	(%)	(Tons)	(%)
Burned Plots										
30	13	7.75	0.27	-97	1.49	-81	0.18	-98	8.29	7
29	19	19.85	0.31	-98	0.24	-99	0.89	-96	4.62	-77
14	22	1.19	0.65	-45	0.49	-59	0.44	-63	4.18	251
5	30	14.59	0.30	-98	0.53	-96	0.48	-97	2.63	-82
3	31	4.22	0.49	-88	0.04	-99	0.17	-96	1.49	-65
27	36	42.72	0.75	-98	1.97	-95	1.24	-97	8.49	-80
28	37	0.81	0.50	-38	0.88	9	0.75	-7	2.58	219
25	39	6.39	4.06	-36	0.69	-89	6.93	8	16.52	159
31	40	18.46	0.51	-97	0.59	-97	0.02	-100	1.50	-92
6	40	30.90	0.84	-97	1.64	-95	7.38	-76	8.30	-73
9	43	31.05	0.61	-98	0.03	-100	0.01	-100	4.23	-86
23	43	4.37	0.49	-89	0.98	-78	0.24	-95	0.00	-100
18	47	8.07	0.50	-94	0.10	-99	0.07	-99	0.04	-100
28	48	0.81	0.50	-38	0.88	9	0.75	-7	2.58	219
10	50	3.36	0.94	-72	0.89	-74	0.66	-80	0.00	-100
2	53	23.58	0.14	-99	0.38	-98	0.19	-99	5.82	-75
1	66	0.34	0.23	-32	0.30	-12	0.01	-97	1.98	482
22	68	11.95	0.63	-95	0.28	-98	0.05	-100	8.74	-27
11	70	26.20	0.32	-99	1.67	-94	0.02	-100	4.04	-85
21	76	3.46	0.40	-88	0.64	-82	4.34	25	0.00	-100
Unburned Plots										
4	0	1.42	---	---	---	---	0.21	-85	12.39	773
7	0	4.26	---	---	---	---	1.32	-69	8.24	93
8	0	1.16	---	---	---	---	0.00	-100	2.62	126
12	0	53.78	---	---	---	---	10.78	-80	10.91	-80
13	0	26.04	---	---	---	---	3.28	-87	6.34	-76
15	0	1.10	---	---	---	---	0.31	-72	0.01	-99
16	0	13.62	---	---	---	---	0.56	-96	9.83	-28
17	0	5.07	---	---	---	---	62.35	1,130	17.03	236
19	0	1.04	---	---	---	---	0.10	-90	1.48	42
20	0	50.59	---	---	---	---	0.77	-98	7.79	-85
24	0	8.50	---	---	---	---	0.00	-100	7.98	-6
32	0	19.74	---	---	---	---	3.88	-80	17.63	-11

Table 2 a

Duff Depths by Treatment Type

Lubrecht Experimental Forest
1972 - 1983

Treatment	Statistic	-1972-	-1973-	-1975-	-1980-	-1983-
Unburned	Mean	2.74	--	--	2.11	2.13
	Std Error	0.12	--	--	0.13	0.09
	Median	2.48	--	--	1.73	1.79
	Transects	156	0	0	156	300
Burned	Mean	2.62	1.07	0.44	1.18	1.09
	Std Error	0.12	0.06	0.02	0.06	0.04
	Median	2.20	0.92	0.42	1.00	0.85
	Transects	260	257	260	260	500
Burned Plots by Burn Severity						
1% - 25%	Mean	3.14	1.75	0.56	1.62	1.46
	Std Error	0.57	0.17	0.06	0.16	0.14
	Median	2.28	1.57	0.44	1.49	1.26
	Transects	39	39	39	39	75
26% - 60%	Mean	2.46	1.05	0.45	1.19	1.12
	Std Error	0.10	0.08	0.02	0.07	0.05
	Median	2.13	0.99	0.44	0.98	0.91
	Transects	169	166	169	169	325
60% - 100%	Mean	2.73	0.63	0.31	0.84	0.70
	Std Error	0.23	0.11	0.03	0.11	0.06
	Median	2.43	0.29	0.28	0.51	0.55
	Transects	52	52	52	52	100
Burned Plots by Season of Burning						
Spring	Mean	2.71	1.36	0.53	1.41	1.51
	Std Error	0.14	0.11	0.03	0.09	0.07
	Median	2.31	1.15	0.47	1.35	1.30
	Transects	117	114	117	117	225
Fall	Mean	2.38	0.84	0.63	1.00	0.74
	Std Error	0.11	0.06	0.02	0.07	0.04
	Median	2.07	0.69	0.34	0.77	0.61
	Transects	143	143	143	143	275

Table 2 b

Fine Fuel Loads by Treatment Type

Lubrecht Experimental Forest
1972 - 1983

Treatment	Statistic	-1972-	-1973-	-1975-	-1980-	-1983-
Unburned	Mean	5.91	--	--	3.73	3.86
	Std Error	0.67	--	--	0.36	0.21
	Median	3.11	--	--	2.17	3.03
	Transects	156	0	0	156	300
Burned	Mean	7.99	3.26	2.91	4.02	4.31
	Std Error	0.80	0.22	0.16	0.32	0.19
	Median	4.03	1.96	2.15	1.93	3.29
	Transects	260	257	260	260	500
Burned Plots by Burn Severity						
1% - 25%	Mean	21.44	2.52	2.23	3.81	3.88
	Std Error	4.31	0.41	0.37	1.07	0.77
	Median	4.38	1.07	1.28	1.57	2.26
	Transects	39	39	39	39	75
26% - 60%	Mean	5.24	3.64	2.93	3.66	3.99
	Std Error	0.42	0.30	0.19	0.31	0.19
	Median	3.78	2.94	2.15	1.93	3.24
	Transects	169	166	169	169	325
60% - 100%	Mean	6.82	2.60	3.35	5.34	5.64
	Std Error	1.01	0.39	0.41	0.97	0.45
	Median	4.19	1.31	2.28	3.05	4.11
	Transects	52	52	52	52	100
Burned Plots by Season of Burning						
Spring	Mean	4.57	3.46	2.48	3.67	4.17
	Std Error	0.47	0.36	0.19	0.39	0.25
	Median	3.33	2.96	1.98	1.93	3.49
	Transects	117	114	117	117	225
Fall	Mean	5.86	3.09	3.25	4.30	4.41
	Std Error	0.53	0.27	0.25	0.50	0.29
	Median	3.97	1.50	2.27	2.38	3.22
	Transects	143	143	143	143	275

Table 2 c

Large Fuel Loads by Treatment Type

Lubrecht Experimental Forest
1972 - 1983

Treatment	Statistic	-1972-	-1973-	-1975-	-1980-	-1983-
Unburned	Mean	41.43	--	--	20.24	13.96
	Std Error	5.84	--	--	3.80	1.19
	Median	5.08	--	--	0.00	7.71
	Transects	156	0	0	156	300
Burned	Mean	33.69	10.99	11.55	8.44	8.13
	Std Error	3.13	2.02	2.44	1.26	0.57
	Median	17.01	0.00	0.00	0.00	4.23
	Transects	260	257	260	260	500
Burned Plots by Burn Severity						
1% - 25%	Mean	52.90	20.93	27.52	4.42	10.57
	Std Error	9.31	9.59	12.82	1.50	2.34
	Median	43.94	0.05	0.02	0.09	4.84
	Transects	39	39	39	39	75
26% - 60%	Mean	32.25	10.49	9.38	9.00	7.96
	Std Error	3.79	1.96	1.88	1.46	0.62
	Median	17.00	0.00	0.01	0.00	4.16
	Transects	169	166	169	169	325
60% - 100%	Mean	23.98	5.15	6.62	9.65	6.82
	Std Error	6.23	2.85	4.13	4.01	0.93
	Median	4.67	0.00	0.02	0.00	4.13
	Transects	52	52	52	52	100
Burned Plots by Season of Burning						
Spring	Mean	38.55	14.77	13.40	9.30	10.45
	Std Error	5.26	3.43	3.48	1.55	1.05
	Median	18.95	0.02	0.02	0.00	5.62
	Transects	117	114	117	117	225
Fall	Mean	26.34	7.97	10.03	7.74	6.22
	Std Error	3.71	2.37	3.41	1.92	0.54
	Median	6.37	0.00	0.00	0.00	2.71
	Transects	143	143	143	143	275

Table 3 a

Effects of Burning on Duff Depth Distributions
Table of Kolmogorov-Smirnov and Mann-Whitney U Test Probabilities
by Treatment Type and Year of Inventory
Lubrecht Experimental Forest

Treatment 1	by	Treatment 2	Test	-1972-	-1980-	-1983-
Unburned	by	All Burned	K-S	0.071	0.000 **	0.000 **
			M-W	0.133	0.000 **	0.000 **
		<30% Burned	K-S	0.744	0.267	0.003 **
			M-W	0.839	0.175	0.000 **
		30-60% Burned	K-S	0.040 *	0.000 **	0.000 **
			M-W	0.077	0.000 **	0.000 **
		>60% Burned	K-S	0.864	0.000 **	0.000 **
			M-W	0.843	0.000 **	0.000 **
		Spring Burns	K-S	0.538	0.011 *	0.000 **
			M-W	0.791	0.000 **	0.000 **
		Fall Burns	K-S	0.046 *	0.000 **	0.000 **
			M-W	0.031 *	0.000 **	0.000 **
<30% Burned	by	30-60% Burned	K-S	0.879	0.002 **	0.000 **
			M-W	0.340	0.004 **	0.071
		>60% Burned	K-S	0.998	0.000 **	0.000 **
			M-W	0.933	0.000 **	0.000 **
30-60% Burned		>60% Burned	K-S	0.649	0.005 **	0.000 **
			M-W	0.271	0.003 **	0.000 **
Spring Burns	by	Fall Burns	K-S	0.170	0.000 **	0.000 **
			M-W	0.059	0.000 **	0.000 **

Table 3 b

Effects of Burning on Fine Fuel Distributions
Table of Kolmogorov-Smirnov and Mann-Whitney U Test Probabilities
by Treatment Type and Year of Inventory
Lubrecht Experimental Forest

Treatment 1	by	Treatment 2	Test	-1972-	-1980-	-1983-
Unburned	by	All Burned	K-S	0.818	0.960	0.554
			M-W	0.990	0.765	0.181
		<30% Burned	K-S	0.011 *	0.684	0.321
			M-W	0.060	0.521	0.120
		30-60% Burned	K-S	0.415	0.788	0.482
			M-W	0.691	0.810	0.339
		>60% Burned	K-S	0.420	0.420	0.003 **
			M-W	0.197	0.346	0.001 **
		Spring Burns	K-S	0.684	0.713	0.474
			M-W	0.385	0.817	0.225
		Fall Burns	K-S	0.434	0.986	0.368
			M-W	0.441	0.784	0.280
<30% Burned	by	30-60% Burned	K-S	0.002 **	0.492	0.130
			M-W	0.085	0.294	0.024 *
		>60% Burned	K-S	0.025 *	0.240	0.003 **
			M-W	0.320	0.245	0.000 **
30-60% Burned		>60% Burned	K-S	0.337	0.303	0.005 **
			M-W	0.275	0.367	0.004 **
Spring Burns	by	Fall Burns	K-S	0.294	0.765	0.702
			M-W	0.113	0.875	0.774

Table 3 c

Effects of Burning on Large Fuel Distributions
Table of Kolmogorov-Smirnov and Mann-Whitney U Test Probabilities
by Treatment Type and Year of Inventory
Lubrecht Experimental Forest

Treatment 1	by	Treatment 2	Test	-1972-	-1980-	-1983-
Unburned	by	All Burned	K-S	0.488	0.071	0.000 **
			M-W	0.713	0.018 *	0.001 **
		<30% Burned	K-S	0.009 **	0.086	0.047 *
			M-W	0.008 **	0.013 *	0.256
		30-60% Burned	K-S	0.191	0.123	0.000 **
			M-W	0.407	0.051	0.002 **
		>60% Burned	K-S	0.543	0.269	0.016 *
			M-W	0.401	0.338	0.007 **
		Spring Burns	K-S	0.140	0.684	0.060
			M-W	0.215	0.315	0.238
		Fall Burns	K-S	0.332	0.011 *	0.000 **
			M-W	0.621	0.018 *	0.000 **
<30% Burned	by	30-60% Burned	K-S	0.002 **	0.675	0.075
			M-W	0.007 **	0.149	0.175
		>60% Burned	K-S	0.002 **	0.305	0.315
			M-W	0.001 **	0.102	0.255
30-60% Burned		>60% Burned	K-S	0.272	0.830	0.355
			M-W	0.098	0.571	0.941
Spring Burns	by	Fall Burns	K-S	0.241	0.201	0.000 **
			M-W	0.078	0.065	0.001 **

Table 4

Changes in Median Fuel Characteristics
by Percent of Plot Area Burned
1972 - 1983

Fuel Parameter	Area Burned	1972 Load	--1973-- Load	Change	--1975-- Load	Change	--1980-- Load	Change	--1983--- Load	Change
0-.25'	0%	0.520	---	---	---	---	0.392	-25	0.165	-68
(tons/ac)	1%-25%	0.520	0.337	-35	0.310	-40	0.390	-25	0.152	-71
	26%-60%	0.530	0.365	-31	0.433	-18	0.462	-13	0.287	-46
	61%-100%	0.575	0.250	-57	0.325	-43	0.440	-23	0.265	-54
.25-1.0'	0%	0.770	---	---	---	---	0.721	-6	0.803	4
(tons/ac)	1%-25%	1.520	0.366	-76	0.364	-76	0.720	-53	0.407	-73
	26%-60%	0.751	0.366	-51	0.792	5	0.780	4	0.832	11
	61%-100%	1.175	0.367	-69	0.740	-37	0.725	-38	1.235	5
1.0-3.0'	0%	0.004	---	---	---	---	0.003	-25	1.580	39,400
(tons/ac)	1%-25%	2.928	0.003	-100	0.003	-100	0.003	-100	1.564	-47
	26%-60%	2.880	0.005	-100	0.005	-100	0.003	-100	1.564	-46
	61%-100%	3.035	0.004	-100	1.405	-54	0.005	-100	3.060	1
>3' Sound	0%	0.023	---	---	---	---	0.001	-96	0.004	-83
(tons/ac)	1%-25%	6.875	0.026	-100	0.100	-99	0.284	-96	3.010	-56
	26%-60%	0.002	0.002	0	0.003	50	0.002	0	2.810	>140,40
	61%-100%	0.130	0.004	-97	0.023	-82	0.004	-97	4.055	3,019
>3' Rotten	0%	0.004	---	---	---	---	0.004	0	1.135	28,275
(tons/ac)	1%-25%	21.971	0.070	-100	0.004	-100	0.406	-98	0.002	-100
	26%-60%	6.370	0.002	-100	0.001	-100	0.003	-100	0.001	-100
	61%-100%	0.085	1.365	1,506	0.559	558	0.123	45	0.021	-75
Duff Depth	0%	2.477	---	---	---	---	1.725	-30	1.785	-28
(Inches)	1%-25%	2.279	1.570	-31	0.438	-81	1.488	-35	1.262	-45
	26%-60%	2.129	0.985	-54	0.443	-79	0.979	-54	0.909	-57
	61%-100%	2.425	0.288	-88	0.275	-89	0.508	-79	0.550	-77
<3' Fines	0%	3.110	---	---	---	---	2.170	-30	3.030	-3
(tons/ac)	1%-25%	4.380	1.070	-76	1.280	-71	1.570	-64	2.260	-48
	26%-60%	3.780	2.935	-22	2.150	-43	1.930	-49	3.240	-14
	61%-100%	4.190	1.305	-69	2.275	-46	3.045	-27	4.110	-2
>3' Large	0%	5.075	---	---	---	---	0.004	-100	7.705	52
(tons/ac)	1%-25%	43.937	0.048	-100	0.019	-100	0.093	-100	4.840	-89
	26%-60%	17.000	0.002	-100	0.005	-100	0.003	-100	4.160	-76
	61%-100%	4.670	0.004	-100	0.023	-100	0.004	-100	4.125	-12

FIGURES

Figure 1 a

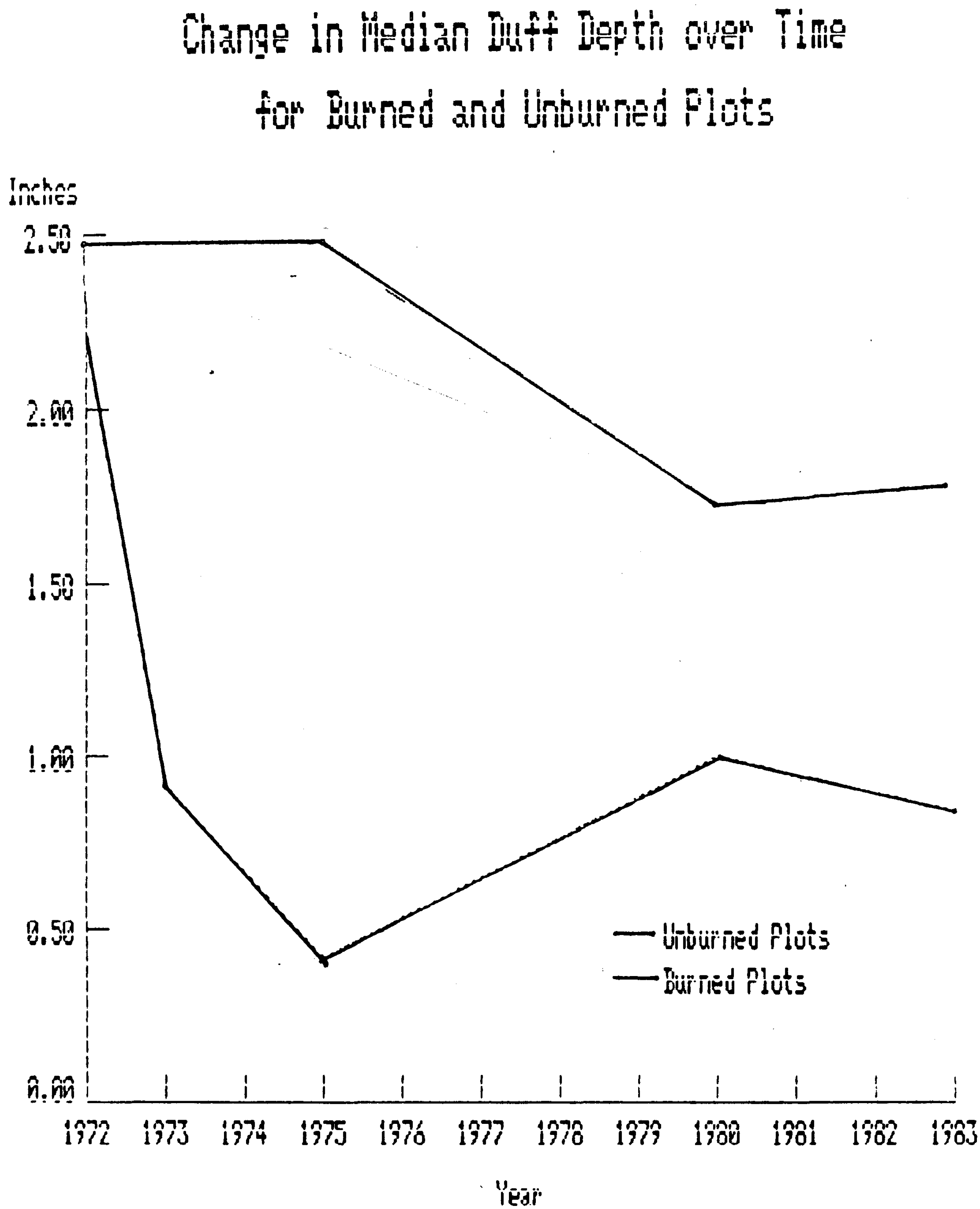
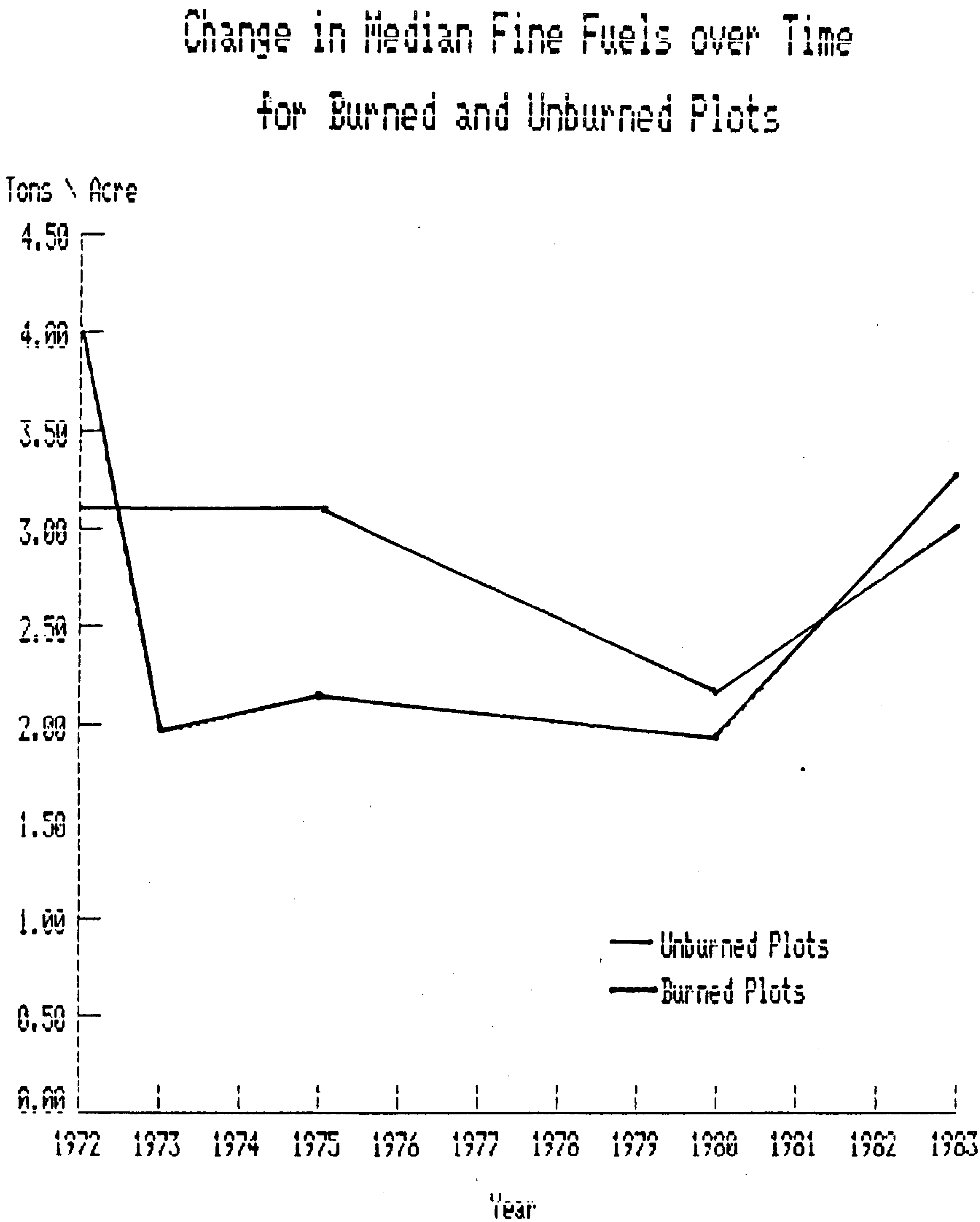

Change in Median Duff Depth over Time
for Burned and Unburned Plots
Inches
2.50
2.00
1.50
1.00
0.50
0.00
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Year
Unburned Plots
Burned Plots

Figure 1 b



Change in Median Fine Fuels over Time
for Burned and Unburned Plots
Tons \ Acre
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Year
Unburned Plots
Burned Plots

Figure 1 c

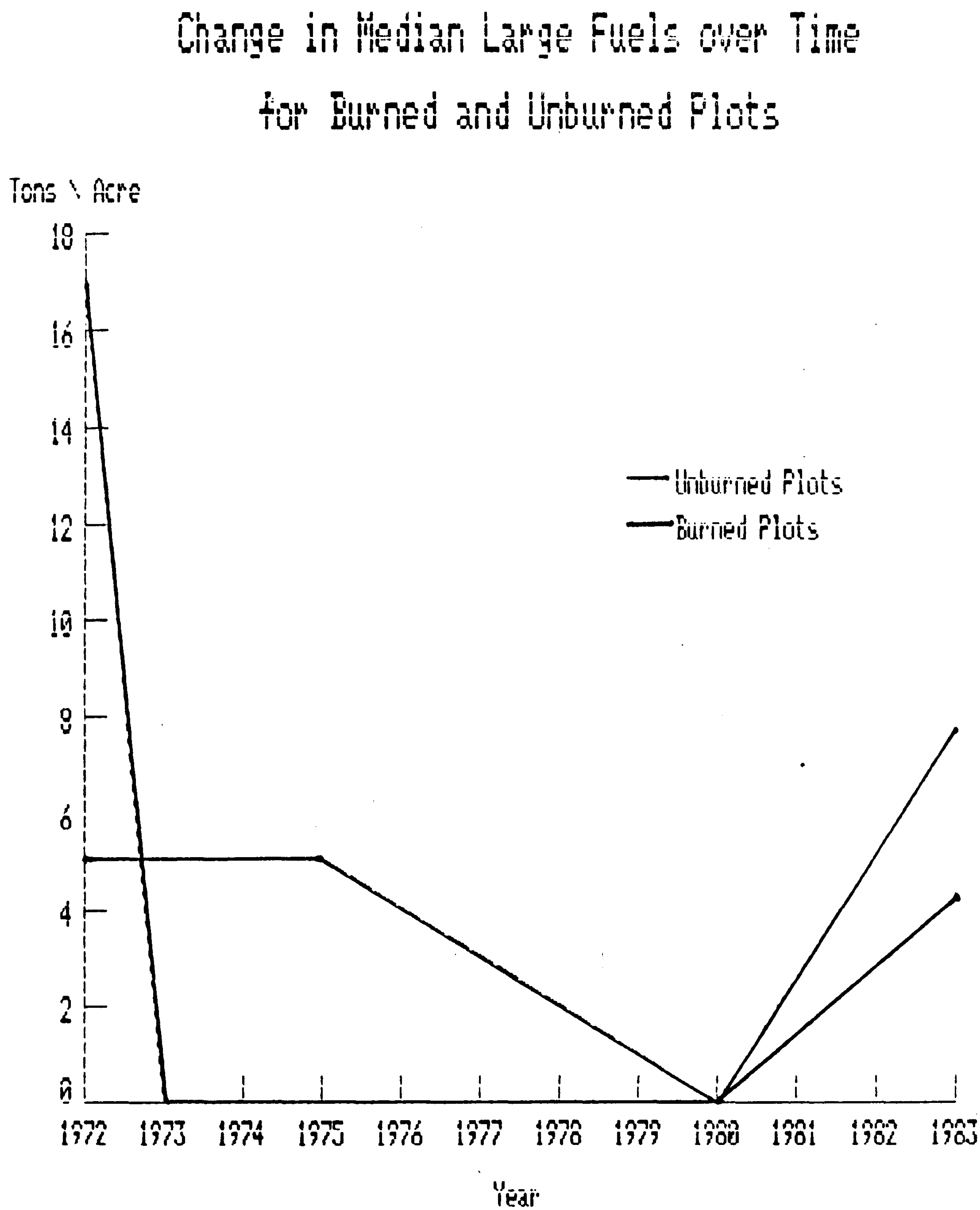
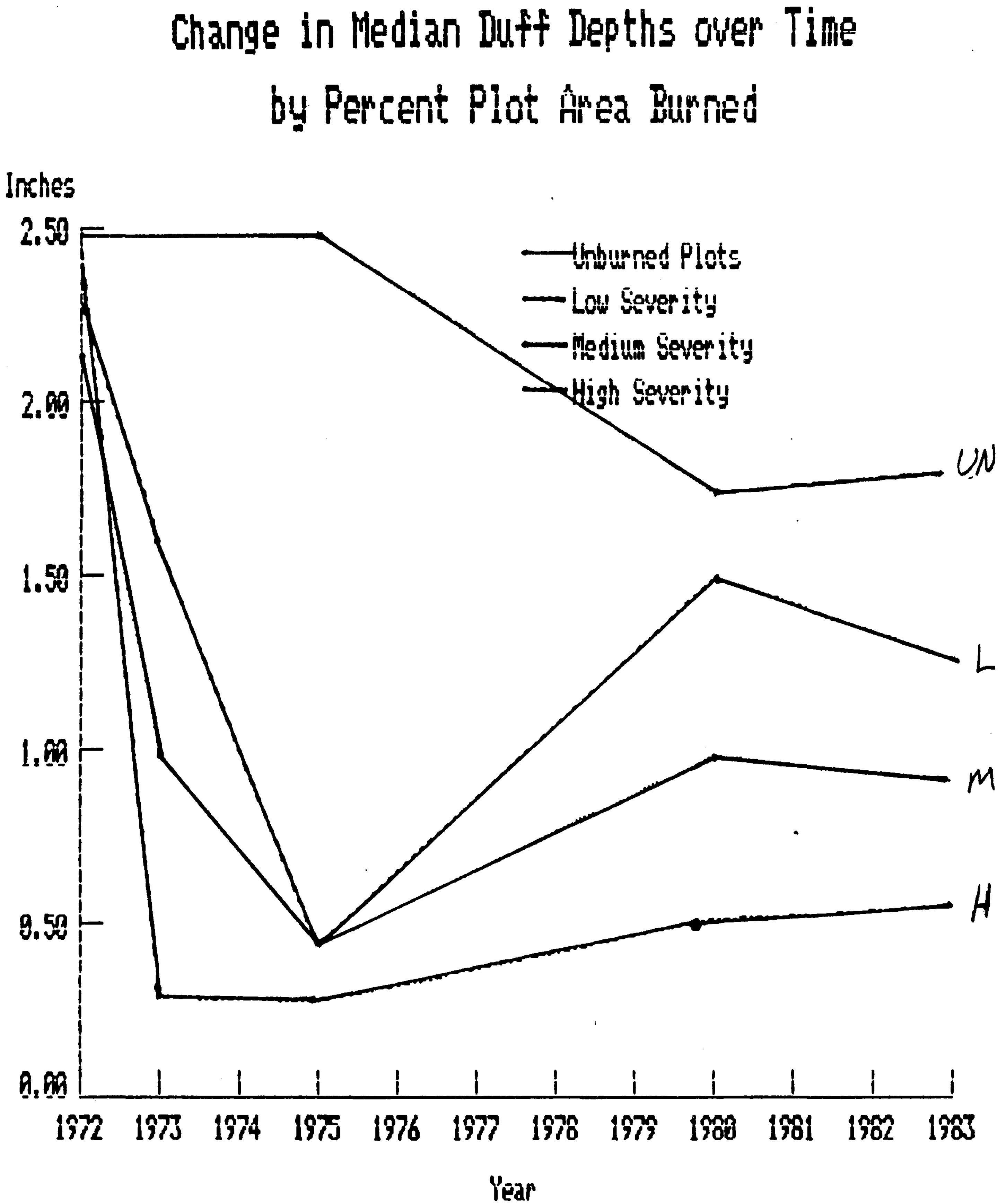
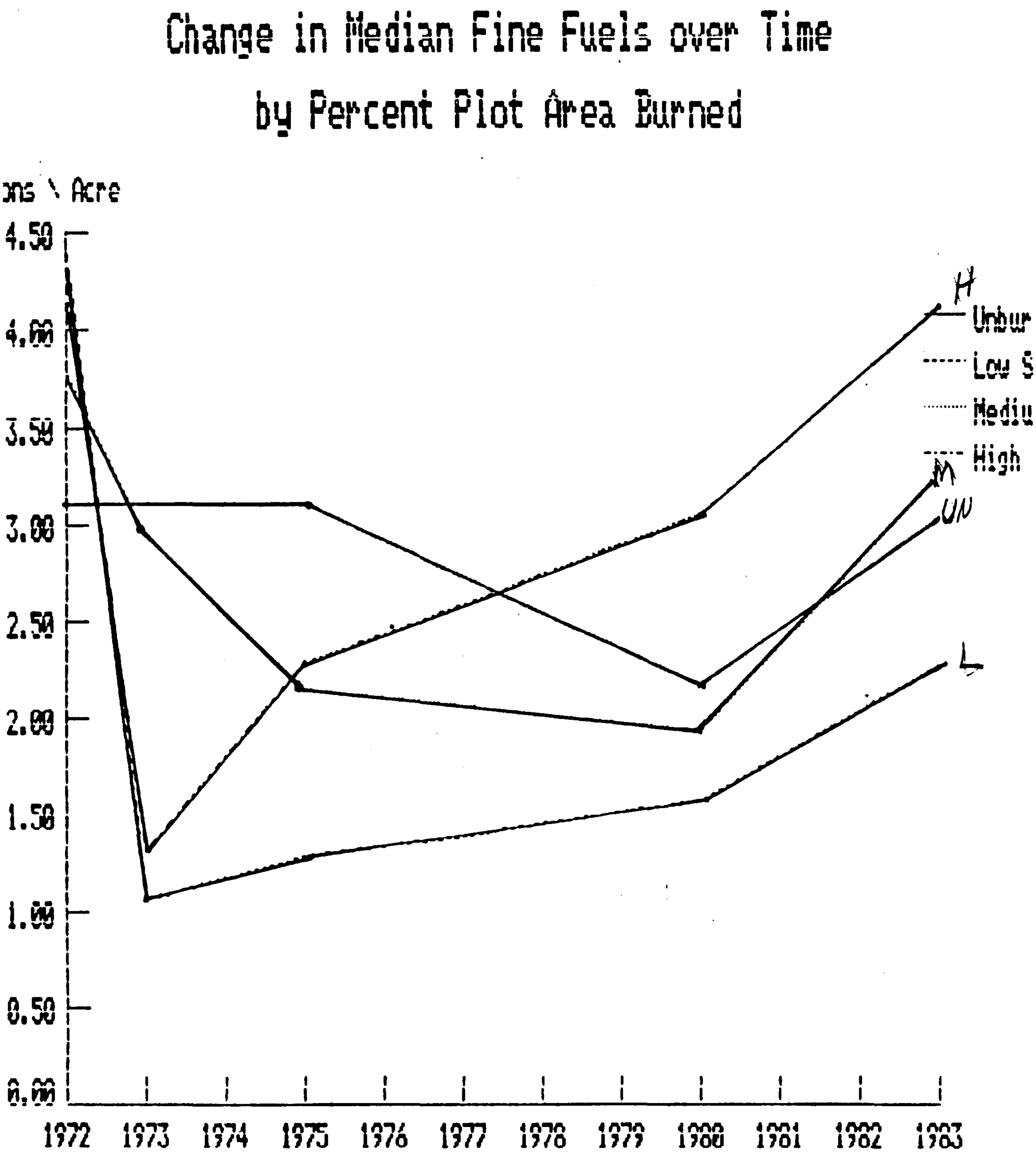

Change in Median Large Fuels over Time
for Burned and Unburned Plots
Tons \ Acre
18
16
14
12
10
8
6
4
2
0
Unburned Plots
Burned Plots
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Year

Figure 2 a



Change in Median Duff Depths over Time
by Percent Plot Area Burned
Inches
2.50
2.00
1.50
1.00
0.50
0.00
Unburned Plots
Low Severity
Medium Severity
High Severity
UN
L
M
H
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Year

Figure 2 b



Change in Median Fine Fuels over Time
by Percent Plot Area Burned
ons \ Acre
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
H
Unbur
Low S
Mediu
High
M
UN
L

Figure 2 c

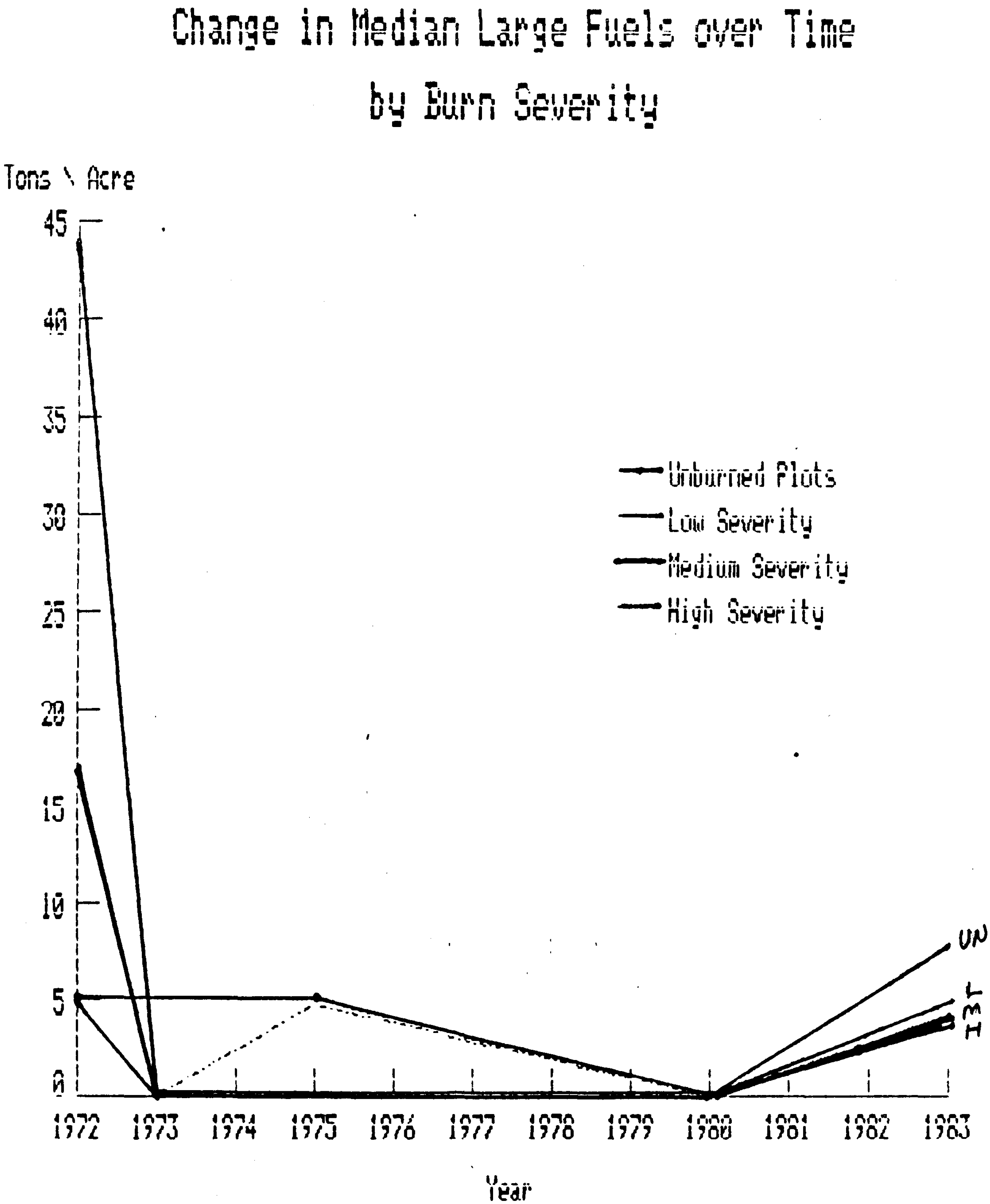

Change in Median Large Fuels over Time
by Burn Severity
Tons \ Acre
45
40
35
30
25
20
15
10
5
0
Unburned Plots
Low Severity
Medium Severity
High Severity
UN
L
M
H
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Year

Figure 3 a

Change in Median Duff Depths over Time

by Season of Burning

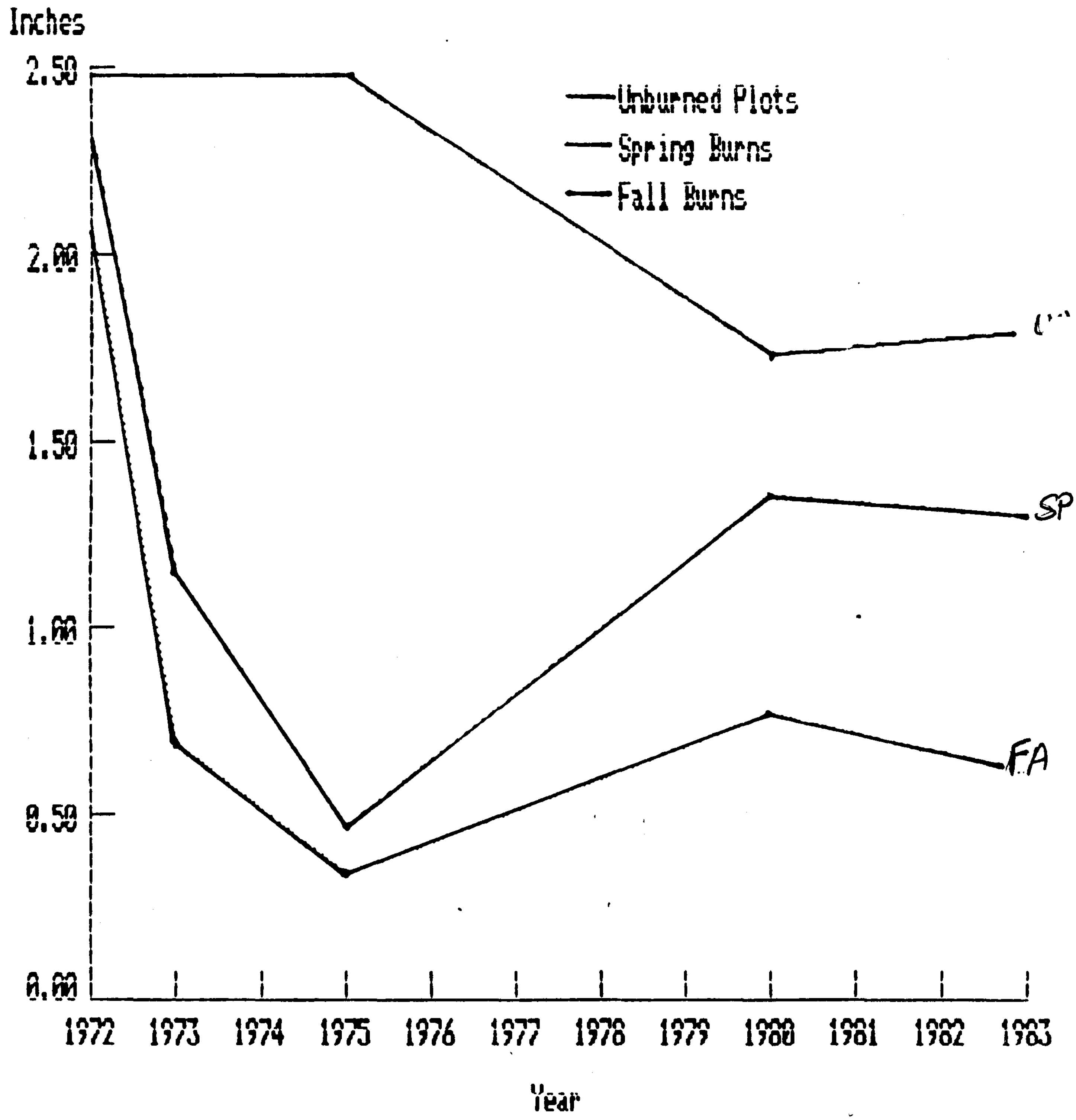


Figure 3 b

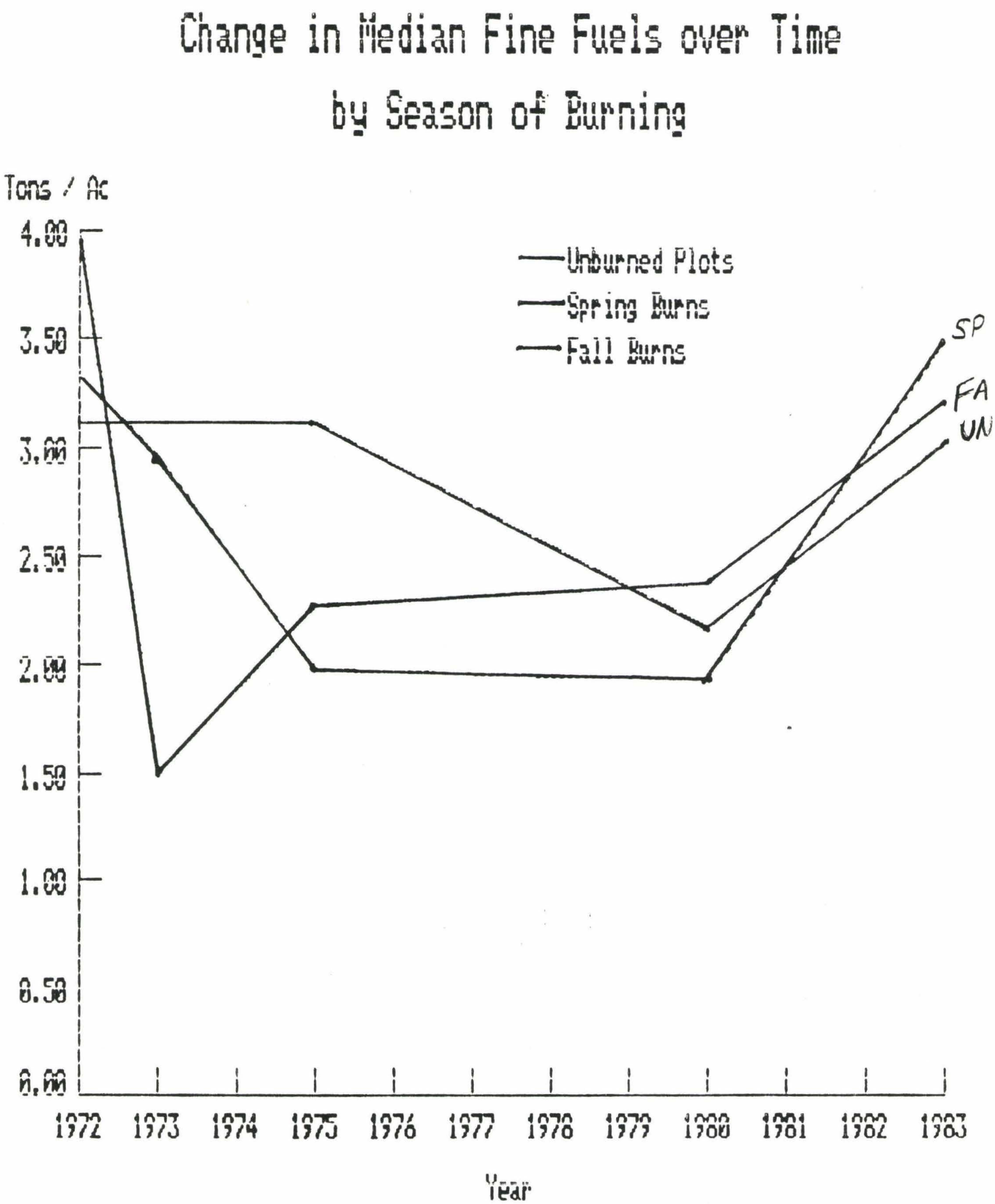
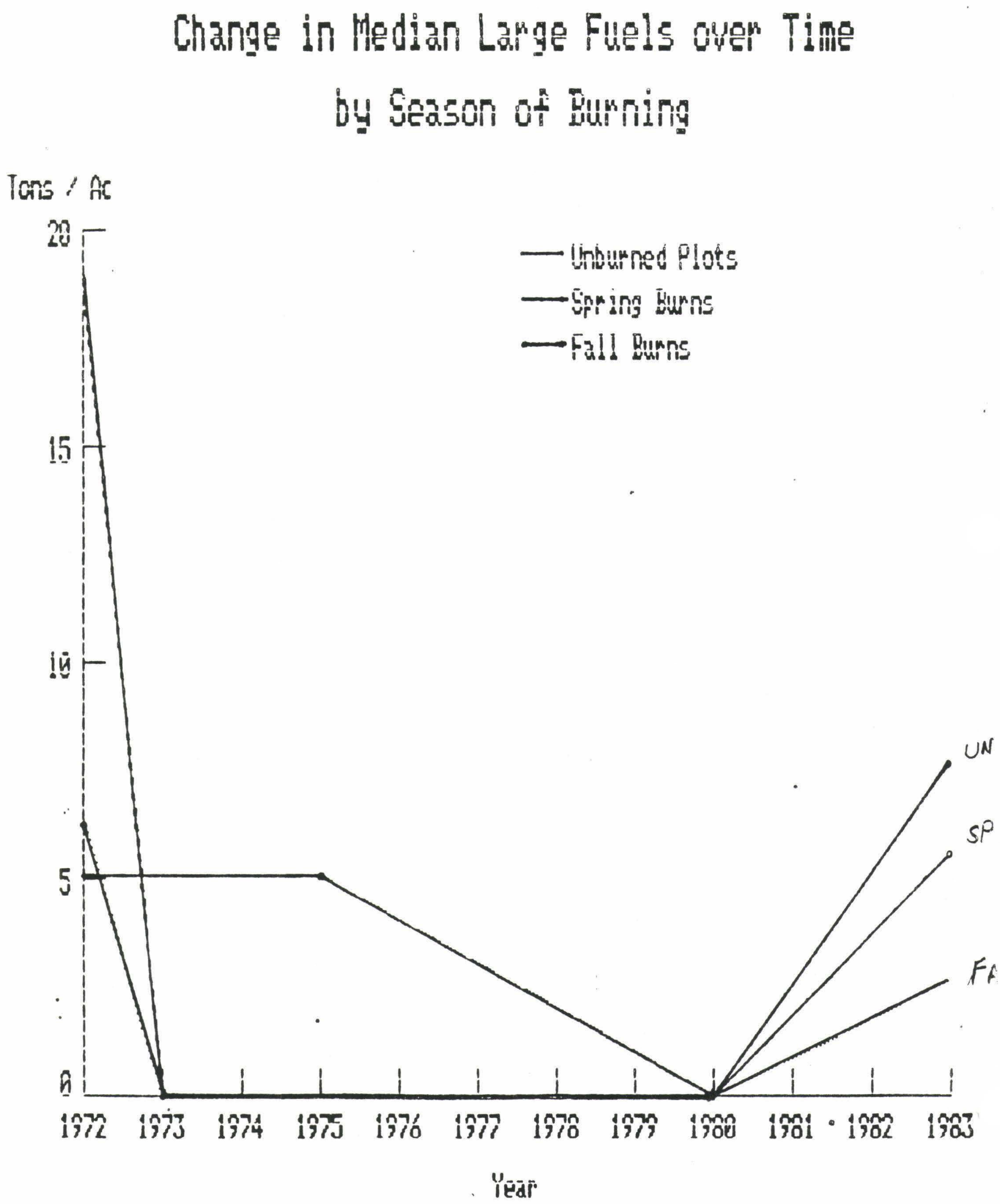

Change in Median Fine Fuels over Time
by Season of Burning
Tons / Ac
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Unburned Plots
Spring Burns
Fall Burns
SP
FA
UN
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Year

Figure 3 c


Change in Median Large Fuels over Time
by Season of Burning
Tons / Ac
20
15
10
5
0
Unburned Plots
Spring Burns
Fall Burns
UN
SP
FA
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
Year